

1 WE CLAIM:

2 1. An apparatus for detecting leaks in a liquid storage
3 tank comprising:

4 differential pressure sensor means having a low
5 pressure measurement component and a high pressure
6 measurement component;

7 protective enclosure means for protecting said
8 differential pressure sensor means from materials
9 and conditions when immersed in liquid contents of
10 said storage tank;

11 said high pressure measurement component being
12 configured for measuring tank bottom pressure
13 within a liquid in which said cannister is
14 immersed;

15 said low pressure measurement component being
16 configured for receiving data indicative of
17 atmospheric pressure substantially at the surface
18 of said liquid

19 barometric pressure measuring means configured for
20 measuring atmospheric pressure substantially at
21 the surface of said liquid when said protective
22 enclosure means is immersed therein;

1 barometric pressure and differential pressure
2 calculation means configured for receiving first
3 and second data reflecting, respectively, said
4 tank bottom pressure and of said barometric
5 pressure substantially at said surface of said
6 liquid, and for adjusting said first data to
7 substantially eliminate variations upon said
8 measurements of said tank bottom pressure caused
9 solely from atmospheric pressure variations to
10 yield an atmospheric pressure adjusted tank bottom
11 pressure;
12 ambient temperature measurement means for measuring
13 ambient temperature near said storage tank;
14 tank dynamic and barometric pressure adjusted tank
15 bottom pressure calculation means configured for
16 receiving third data indicative of said
17 atmospheric pressure adjusted tank bottom
18 pressure, for receiving fourth data indicative of
19 ambient temperature measurements by said ambient
20 temperature measurement means, for receiving fifth
21 data indicative of expansion characteristics of
22 said storage tank, and for adjusting said third
23 data with reference to said fourth and fifth data

1 to substantially eliminate variations upon
2 measurements and calculations of said barometric
3 pressure adjusted tank bottom pressure, caused
4 solely by dimensional changes in said storage tank
5 resulting from atmospheric temperature variations,
6 to yield a tank dynamic adjusted tank bottom
7 pressure;

8 tank content mass calculation means for calculating
9 mass contents of said storage tank substantially
10 based on said tank dynamic adjusted tank bottom
11 pressure and user input data reflecting physical
12 characteristics of said contents of said storage
13 tank.

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15 2. The apparatus of Claim 1 wherein said protective
16 enclosure means is configured for maintaining at least some
17 components of said apparatus within said canister, including
18 said differential pressure sensor, but excepting said low
19 pressure measurement component and said high pressure
20 measurement component, in a substantial vacuum.

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22 3. The apparatus of Claim 1 further comprising protective
23 enclosure temperature management means configured for

1 maintaining the temperature of said protective enclosure
2 substantially at a user-specified temperature.
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4 4. The apparatus of Claim 2 further comprising protective
5 enclosure temperature management means configured for
6 maintaining the temperature of said protective enclosure
7 substantially at a user-specified temperature.
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1 5. An apparatus for detecting leaks in a liquid storage
2 tank comprising:
3 differential pressure sensor means having a low
4 pressure measurement component and a high pressure
5 measurement component;
6 protective enclosure means for protecting said
7 differential pressure sensor means from materials
8 and conditions when immersed in liquid contents of
9 said storage tank;
10 said high pressure measurement component being
11 configured for measuring tank bottom pressure
12 within a liquid in which said cannister is
13 immersed;
14 said low pressure measurement component being
15 configured for receiving data indicative of
16 atmospheric pressure substantially at the surface
17 of said liquid
18 first barometric pressure measuring means configured
19 for measuring atmospheric pressure substantially
20 at the surface of said liquid when said protective
21 enclosure means is immersed therein and for
22 communicating such measurement to said low side

1 measurement component of said differential
2 pressure sensor;

3 second barometric pressure measuring means configured
4 for measuring atmospheric pressure substantially
5 at the surface of said liquid when said protective
6 enclosure means is immersed therein;

7 barometric pressure and differential pressure
8 calculation means configured for receiving first
9 and second data reflecting, respectively, said
10 tank bottom pressure and of said barometric
11 pressure as measured by said first barometric
12 pressure measuring means and for calculating
13 pressure attributable to liquid content of said
14 storage tank, and receiving third data from said
15 second barometric measuring means and, based
16 thereon, adjusting said pressure attributable to
17 said contents of said storage tank to
18 substantially eliminate variations upon said
19 measurements thereof caused solely from
20 atmospheric pressure variations to yield an
21 atmospheric pressure adjusted tank bottom
22 pressure;

1 ambient temperature measurement means for measuring
2 ambient temperature near said storage tank;
3 tank dynamic and barometric pressure adjusted tank
4 bottom pressure calculation means configured for
5 receiving fourth data indicative of said
6 atmospheric pressure adjusted tank bottom
7 pressure, for receiving fifth data indicative of
8 ambient temperature measurements by said ambient
9 temperature measurement means, for receiving sixth
10 data indicative of expansion characteristics of
11 said storage tank, and for adjusting said fourth
12 data with reference to said fifth and sixth data
13 to substantially eliminate variations upon
14 measurements and calculations of said barometric
15 pressure adjusted tank bottom pressure, caused
16 solely by dimensional changes in said storage tank
17 resulting from atmospheric temperature variations,
18 to yield a tank dynamic adjusted tank bottom
19 pressure;
20 tank content mass calculation means for calculating
21 mass contents of said storage tank substantially
22 based on said tank dynamic adjusted tank bottom
23 pressure and user input data reflecting physical

1 characteristics of said contents of said storage
2 tank.
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4 6. The apparatus of Claim 5 wherein said protective
5 enclosure means is configured for maintaining at least some
6 components of said apparatus within said canister, including
7 said differential pressure sensor, but excepting said low
8 pressure measurement component and said high pressure
9 measurement component, in a substantial vacuum.
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11 7. The apparatus of Claim 5 further comprising
12 protective enclosure temperature management means configured
13 for maintaining the temperature of said protective enclosure
14 substantially at a user-specified temperature.
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16 8. The apparatus of Claim 6 further comprising
17 protective enclosure temperature management means configured
18 for maintaining the temperature of said protective enclosure
19 substantially at a user-specified temperature.
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1 9. A method for detecting leaks in a storage
2 receptacle; comprising the steps of:
3 selecting a mass detection system comprising:
4 differential pressure sensor means having a low
5 pressure measurement component and a high
6 pressure measurement component;
7 protective enclosure means for protecting said
8 differential pressure sensor means from
9 materials and conditions when immersed in
10 liquid contents of said storage tank;
11 said high pressure measurement component being
12 configured for measuring tank bottom pressure
13 within a liquid in which said cannister is
14 immersed;
15 said low pressure measurement component being
16 configured for receiving data indicative of
17 atmospheric pressure substantially at the
18 surface of said liquid
19 barometric pressure measuring means configured for
20 measuring atmospheric pressure substantially
21 at the surface of said liquid when said
22 protective enclosure means is immersed
23 therein;

1 barometric pressure and differential pressure
2 calculation means configured for receiving
3 first and second data reflecting,
4 respectively, said tank bottom pressure and
5 of said barometric pressure substantially at
6 said surface of said liquid, and for
7 adjusting said first data to substantially
8 eliminate variations upon said measurements
9 of said tank bottom pressure caused solely
10 from atmospheric pressure variations to yield
11 an atmospheric pressure adjusted tank bottom
12 pressure;

13 ambient temperature measurement means for
14 measuring ambient temperature near said
15 storage tank;

16 tank dynamic and barometric pressure adjusted tank
17 bottom pressure calculation means configured
18 for receiving third data indicative of said
19 atmospheric pressure adjusted tank bottom
20 pressure, for receiving fourth data
21 indicative of ambient temperature
22 measurements by said ambient temperature
23 measurement means, for receiving fifth data

1 indicative of expansion characteristics of
2 said storage tank, and for adjusting said
3 third data with reference to said fourth and
4 fifth data to substantially eliminate
5 variations upon measurements and calculations
6 of said barometric pressure adjusted tank
7 bottom pressure, caused solely by dimensional
8 changes in said storage tank resulting from
9 atmospheric temperature variations, to yield
10 a tank dynamic adjusted tank bottom pressure;
11 tank content mass calculation means for
12 calculating mass content data representative
13 of the contents of said storage tank
14 substantially based on said tank dynamic
15 adjusted tank bottom pressure and user input
16 data reflecting physical characteristics of
17 said contents of said storage tank;
18 selecting data storage means for collecting a plurality
19 of mass content data as generated by said tank
20 content mass calculation means over a plurality of
21 points in time;
22 selecting computing means configured for generating a
23 human perceptible indicating of changes in said

1 mass content data between a plurality of said
2 points in time;
3 placing said protective enclosure means substantially
4 at a bottom interior surface of said storage tank;
5 actuating said mass detection system; and
6 observing data indicative of changes in said mass
7 content data attributable to leakage of said
8 storage tank to detect of such leakage.

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10 10. The method of Claim 9 further comprising the steps of:
11 securing all input and outflow orifices of said storage
12 tank before said actuation of said mass detection
13 system; and
14 substantially selectively processing said mass content
15 data which were generated approximately between
16 sunset and sunrise at an installation site of said
17 system.

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19 11. The apparatus of Claim 9 wherein said protective
20 enclosure means is configured for maintaining at least some
21 components of said apparatus within said canister, including
22 said differential pressure sensor, but excepting said low

1 pressure measurement component and said high pressure
2 measurement component, in a substantial vacuum.
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4 12. The apparatus of Claim 10 wherein said protective
5 enclosure means is configured for maintaining at least some
6 components of said apparatus within said canister, including
7 said differential pressure sensor, but excepting said low
8 pressure measurement component and said high pressure
9 measurement component, in a substantial vacuum.
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11 13. The apparatus of Claim 9 further comprising protective
12 enclosure temperature management means configured for
13 maintaining the temperature of said protective enclosure
14 substantially at a user-specified temperature.
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16 14. The apparatus of Claim 11 further comprising protective
17 enclosure temperature management means configured for
18 maintaining the temperature of said protective enclosure
19 substantially at a user-specified temperature.
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21 15. The apparatus of Claim 12 further comprising protective
22 enclosure temperature management means configured for

1 maintaining the temperature of said protective enclosure
2 substantially at a user-specified temperature.
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4 16. A method for detecting leaks in a storage
5 receptacle; comprising the steps of:

6 differential pressure sensor means having a low
7 pressure measurement component and a high
8 pressure measurement component;

9 protective enclosure means for protecting said
10 differential pressure sensor means from
11 materials and conditions when immersed in
12 liquid contents of said storage tank;

13 said high pressure measurement component being
14 configured for measuring tank bottom pressure
15 within a liquid in which said cannister is
16 immersed;

17 said low pressure measurement component being
18 configured for receiving data indicative of
19 atmospheric pressure substantially at the
20 surface of said liquid

21 first barometric pressure measuring means
22 configured for measuring atmospheric pressure
23 substantially at the surface of said liquid

1 when said protective enclosure means is
2 immersed therein and for communicating such
3 measurement to said low side measurement
4 component of said differential pressure
5 sensor;

6 second barometric pressure measuring means
7 configured for measuring atmospheric pressure
8 substantially at the surface of said liquid
9 when said protective enclosure means is
10 immersed therein;

11 barometric pressure and differential pressure
12 calculation means configured for receiving
13 first and second data reflecting,
14 respectively, said tank bottom pressure and
15 of said barometric pressure as measured by
16 said first barometric pressure measuring
17 means and for calculating pressure
18 attributable to liquid content of said
19 storage tank, and receiving third data from
20 said second barometric measuring means and,
21 based thereon, adjusting said pressure
22 attributable to said contents of said storage
23 tank to substantially eliminate variations

1 upon said measurements thereof caused solely
2 from atmospheric pressure variations to yield
3 an atmospheric pressure adjusted tank bottom
4 pressure;

5 ambient temperature measurement means for
6 measuring ambient temperature near said
7 storage tank;

8 tank dynamic and barometric pressure adjusted tank
9 bottom pressure calculation means configured
10 for receiving fourth data indicative of said
11 atmospheric pressure adjusted tank bottom
12 pressure, for receiving fifth data indicative
13 of ambient temperature measurements by said
14 ambient temperature measurement means, for
15 receiving sixth data indicative of expansion
16 characteristics of said storage tank, and for
17 adjusting said fourth data with reference to
18 said fifth and sixth data to substantially
19 eliminate variations upon measurements and
20 calculations of said barometric pressure
21 adjusted tank bottom pressure, caused solely
22 by dimensional changes in said storage tank
23 resulting from atmospheric temperature

1 variations, to yield a tank dynamic adjusted
2 tank bottom pressure;
3 tank content mass calculation means for
4 calculating mass contents of said storage
5 tank substantially based on said tank dynamic
6 adjusted tank bottom pressure and user input
7 data reflecting physical characteristics of
8 said contents of said storage tank;
9 selecting data storage means for collecting a plurality
10 of mass content data as generated by said tank
11 content mass calculation means over a plurality of
12 points in time;
13 selecting computing means configured for generating a
14 human perceptible indicating of changes in said
15 mass content data between a plurality of said
16 points in time;
17 placing said protective enclosure means substantially
18 at a bottom interior surface of said storage tank;
19 actuating said mass detection system; and
20 observing data indicative of changes in said mass
21 content data attributable to leakage of said
22 storage tank to detect of such leakage.
23

1 17. The method of Claim 16 further comprising the steps of:
2 securing all input and outflow orifices of said storage
3 tank before said actuation of said mass detection
4 system; and
5 substantially selectively processing said mass content
6 data which were generated approximately between
7 sunset and sunrise at an installation site of said
8 system.

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10 18. The apparatus of Claim 16 wherein said protective
11 enclosure means is configured for maintaining at least some
12 components of said apparatus within said canister, including
13 said differential pressure sensor, but excepting said low
14 pressure measurement component and said high pressure
15 measurement component, in a substantial vacuum.

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17 19. The apparatus of Claim 17 wherein said protective
18 enclosure means is configured for maintaining at least some
19 components of said apparatus within said canister, including
20 said differential pressure sensor, but excepting said low
21 pressure measurement component and said high pressure
22 measurement component, in a substantial vacuum.
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1 20. The apparatus of Claim 16 further comprising protective
2 enclosure temperature management means configured for
3 maintaining the temperature of said protective enclosure
4 substantially at a user-specified temperature.

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6 21. The apparatus of Claim 17 further comprising protective
7 enclosure temperature management means configured for
8 maintaining the temperature of said protective enclosure
9 substantially at a user-specified temperature.

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11 22. The apparatus of Claim 18 further comprising protective
12 enclosure temperature management means configured for
13 maintaining the temperature of said protective enclosure
14 substantially at a user-specified temperature.